Requirement ID: 931

Sponsor Organization: ACE-111   Sponsor POC: Frank Bick

Keywords: Automation, General Aviation Pilots (GA), Interface Design, Performance (meas/imprv), Procedures

Title: Electronic Primary and Multi-function Flight Displays for GA; Certification Criteria and Usability Assessments

Research Statement:
The intent of this research requirement is to identify factors salient to the design and certification of primary flight displays and multi-function displays that may contain terrain representations and flight guidance cues and to quantify their effects upon pilot performance (flight technical error, procedural performance, terrain awareness, usability). The questions involve not only anticipated certification submissions, but also the displays already acquired and being installed for the Capstone program. The breadth of the requirement is intended to include any platform or means for presenting this information in the cockpit. The research will consist of two tasks. <p><u>Task 1</u> will involve the examination of a number of display factors expected to affect pilot performance that should be addressed by the certification process. Not all of the listed issues will necessarily be addressed by empirical research, particularly where there are extant data pertaining to the question. Issues to be examined will include but not be limited to: Depiction of horizon and guidance information, independent from the terrain, to guarantee its availability to the pilot; terrain format (solid, wire-frame, etc.) and presence/absence; indications in extreme attitudes (aiding recovery) and during failures; point of regard (viewing vector) and field of view; use of pitch ladders; color-coding schemes; comparison with baseline standard instrumentation; substitution of other display enhancements for HITS-format guidance when terrain depiction is present; fixed-field versus movable-field displays. A summary of extant data will be prepared and empirical research will be used, where practical, to obtain those data not available in the literature.<p><u>Task 2</u> will involve an examination of the impact of Capstone (Phase II) avionics on the flight operations in the Juneau area, with specific attention to training requirements/adequacy, usability, and overall effectiveness. This is an extension/continuation of evaluations conducted under Phase I of the Capstone effort and will include systems from each phase. Continuing evaluations will include the impact of national implementation of the Capstone systems.. Issues to be assessed include the use of the equipment in single-pilot operations and use of the equipment by pilots of varying experience levels. Flight operations examined will include those conducted under IFR and VFR.. An assessment of the multi-function flight display will include flight planning operations and changing flight plans in flight. Use and effectiveness of these displays under unusual (failure) conditions will also be assessed. Identification of specific problem areas will be fed back into Task 1.

Background:
Recent applications for certification of electronic flight displays have included aircraft

attitude instrumentation/primary flight displays that depict perspective terrain as well as basic attitude information. In some cases there are also data for airspeed, altitude, and other flight-performance parameters. The manner in which these data are "integrated" can have a significant effect on pilot performance, particularly if the combining leads to clutter or the obscuration of key data because of inappropriate layering schemes. Data are needed to aid certification personnel in assessing which display formats, if any, will produce acceptable levels of safety in operations using these terrain-inclusive displays. Phase II of the Capstone program, to be centered in Juneau, will provide an opportunity to examine PFDs and MFDs in an operational environment and to assess their effectiveness as designed and installed. This exercise, however, will not allow display variables to be manipulated to determine which have serious effects on pilot performance and flight safety. Thus, a parallel program of simulator research is intended to assess the effects of varying formats and presentations of the displayed information. Experimentation will cover any forms of display (head-down panel-mounted, head-up, head- or helmet-mounted) that are permanently installed in the aircraft and depict terrain or terrain with separate attitude indications as the primary means of assessing aircraft attitude. The data required include but are not limited to graphical formatting of the terrain for presentation with attitude information (issues involving wire-frame, texture, color, transparency, priority of data), requirements for and formatting of attitude indices separate from the terrain depiction, and workload issues associated with major variations in display format. There is an ongoing concern about the presentation of command guidance information on primary flight displays, including various forms of flight directors and highway-in-the-sky formats (something to be included in the Capstone II PFD). Applicants for certification of new displays are now looking at using pathway formats for primary guidance, and data are needed by the certification community to determine how the level of safety attainable with these displays compares with that currently attainable with more conventional presentations, and if there are format issues that have critical impacts on pilot performance. Some of these data concerning display format effects are already available, but baseline data for performance with a flight-director display are needed that are directly comparable with those data already collected for pathway-format displays. An additional concern when using such displays is to what degree the data provided are sufficient for maintaining attitude and altitude awareness. That is, to what extent can the terrain data alone be used as an attitude reference and as a means of maintaining separation from the terrain and obstacles on the terrain? The degree to which the displays provide usable information will directly impact the efficacy of use for recovery from unusual or unknown attitudes and the avoidance of controlled-flight-into-terrain accidents. Although it is expected that the terrain representation will serve as a redundant cue for both attitude and altitude information, reasons exist to believe that the pictorial nature of the presentation may make it compelling and that it can and may exert a disproportionate influence over the pilot's interpretation of the overall situation. A number of platforms are now available or being submitted for approval to present this type of information, and.while it is recognized that the FAA does not have regulatory authority over some of them (hand-held/portable), this examination is expected to encompass systems that are either currently available or are expected to be viable within the near future. This will allow a comprehensive database to be developed to anticipate the present and future needs of Aircraft Certification, and to serve as a potential source

for Advisory Circulars where regulatory action is not possible or warranted.

Output:
<u>Task 1:</u> The performing activity will determine what factors are the major contributors to significant variations in pilot performance resulting from the use of terrain representations in primary flight displays, assess differences in pilot performance between "baseline" instrumentation and terrain-inclusive presentations for selected representative piloting tasks, and provide a summary of these findings in a form that certification personnel can use to determine the acceptability of displays, based upon human factors/human performance criteria, submitted for certification.Specific questions to be addressed will include: horizon depiction format, terrain format, control of terrain presence/absence, off-screen indicators, field of view, point of regard, aspect ratio, color coding, pitch quantification, HITS alternative, and comparison with conventional instrumentation.<p><u>Task 2:</u> The results of interviews, to be conducted with pilots in the Juneau area who are using Capstone II equipment, will be analyzed and reported, with specific attention to training and human factors issues. The results of usability studies, using flight-simulation resources, will be reported for the Capstone I and II displays, with specific attention to single-pilot operations in high-workload conditions. Results related to human factors, training, and safety issues will be used to establish training and display design guidelines.

Regulatory Link:
<u>Task 1:</u> The sponsor will use the data to refine guidelines for the certification of PFDs containing terrain depictions and/or perspective graphical flight-path guidance indicators. The data will also be used to generate appropriate guidance documentation (certification check lists, advisory circulars, guidelines for potential applicants, other documents) where applicable.<p> <u>Task 2:</u> Human Factors Issues for ADS-B Applications, Volume 4: Flight Safety, Revision A.